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TEMPERATURE MEASUREMENT INSIDE A JIMSPHERE BALLOON

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16. Abstract

An experiment was conducted to determine the difference in the temperature inside a Jimsphere balloon and the ambient temperature during actual free-flight of the Jimsphere. The temperature inside the Jimsphere was measured to determine the lapse rate of the helium temperature during normal flight conditions and to infer the effects that the balloon temperature may have on the ambient temperature.

For this experiment, a standard AMT-4 radiosonde was used to measure the ambient temperature and the humidity circuit modified to accept a thermistor to measure the balloon temperature.

Six flights were made, three of which were made in daylight and three under nighttime conditions. It was found that balloon temperature lapse rate was not so great as the ambient temperature lapse rate. At times, the balloon temperature was as much as 25°C higher than the ambient temperature during daylight flights. During nighttime, the departure was not nearly so great, with the balloon temperature being generally lower than the ambient temperature.

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SUMMARY

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For this experiment, a standard AMT-4 radiosonde was used to measure the ambient temperature and the humidity circuit modified to accept a thermistor to measure the balloon temperature.

Six flights were made, three of which were made in daylight and three under nighttime conditions. It was found that balloon temperature lapse rate was not so great as the ambient temperature lapse rate. At times, the balloon temperature was as much as 25°C higher than the ambient temperature during daylight flights. During nighttime, the departure was not nearly so great, with the balloon temperature being generally lower than the ambient temperature.

I. INTRODUCTION

An experiment was conducted to determine the difference in the temperature inside a Jimsphere balloon and the ambient temperature during natural free-flight of the Jimsphere. It was desired to measure the temperature inside the Jimsphere to determine the lapse rate of the helium temperature during normal flight conditions, and to infer the effects that the temperature inside the balloon may have on the rise rates. For this particular experiment, a standard AMT-4 radiosonde was used to measure the ambient temperature and the humidity circuit modified to accept a thermistor to measure the temperature inside the balloon.

II. DESCRIPTION OF EQUIPMENT

A radiosonde AN/AMT-4 and an AN/GMD-2A radio direction finder were used in this test to measure the desired parameters. The radiosonde consists of a transmitter, modulator, battery, and elements for sensing pressure, temperature and humidity. The radiosonde is carried to altitudes in excess of 30 km by a helium-filled balloon.

The battery is the power source for the modulator and transmitter. The transmitter operates in the 1660 to 1700 MHz band. Its carrier is pulsed at an audio-frequency rate by the pressure, temperature, and humidity sensing elements.

The temperature element consists of a thermistor whose resistance varies inversely with temperature, and the humidity element consists of a carbon-coated hygristor whose resistance varies directly with humidity. The atmospheric pressure is obtained by a baroswitch which contains an aneroid cell.

The variation of atmospheric pressure acting on the aneroid capsule as it is carried aloft will operate a sensor mechanism causing a contact arm and pointer to move across a commutator. The commutator, consisting of insulating (temperature) and conducting (humidity) segments, becomes a switching arrangement which sends the input to the modulated self-blocking oscillator in the transmitter to be changed in accordance with the atmospheric factors of temperature and humidity.

The carrier frequency of the transmitter is modulated by the self-blocking oscillator at an audio-frequency rate. The audio-frequency is a function of temperature, humidity, and reference signal (or pressure indicator).

The transmitted signals are received, recorded, and evaluated in accordance with instructions given in Federal Meteorological Handbook No. 3, "Radiosonde Observation."

Balloon, meteorological, radar reflective, ML-632/UM is a two-meter diameter sphere with 398 conical roughness elements formed into 1/2 mil metalized mylar used as the fabrication material. The sphere is constructed of twelve gores and two end caps. Six gores, spaced alternately, have 32 projections each and 34 projections are located in each of the remaining six gores. One projection is located in each of the end caps. The projections are full cones, 7.62 centimeters (3 inches) high, 7.62 centimeters (3 inches) in diameter at the base, and spaced 18.95 centimeters (7.5 inches) apart.

The ML-632/UM Balloon, popularly designated "Jimsphere," has a lightweight plastic inflation valve, one-half inch in diameter, and approximately one inch long. The inflation valve has a nylon diffuser bag and a snap-on or screw closure cap. Two lightweight plastic pressure relief valves, spring loaded to provide 5 mb superpressure, are located one each near the polar caps. A nylon load patch used to hold the balloon during inflation is located near the inflation valve. A 100-gram ballast weight used for stabilization purposes is located in the hold-down patch. The average weight with ballast of the Jimsphere is 407.9 grams.

The Jimsphere is used with the AN/FPS-16 high-precision radar to obtain detailed profiles of winds and wind-shear data from the launch site to an altitude of 18 km. This information is used for operational support space vehicles, missiles, and rocket launchings at the national ranges, and to aid in the design of space vehicles, missiles, and rocket systems.

For this particular experiment, the ambient temperature and the temperature of the helium inside the balloon were measured. The humidity sensing circuitry was modified to be identical to that of the temperature sensing circuit. Thus, an additional thermistor was added and used as the second temperature element inside the Jimsphere.

To compute altitude accurately, the relative humidity valve is required. A radiosonde was released simultaneously with the test flight to supply relative humidity necessary for altitude computation. The relative humidity was then taken from the routine flight and used in the computation of altitude for the experimental flight.

The flight data were then manually reduced according to Federal Meteorological Handbook No. 3, "Radiosonde Observation."

Six flights were made during this experiment, three flights during the daylight hours and the remaining three at night. The balloons used in this test were the Jimsphere, ML-632/UM (Government Nomenclature). The weights varied from 400 grams to 410 grams. Inflated diameter was two meters ± 1 percent (excluding roughness elements). Each Jimsphere had a free lift of 3700 grams.

III. DETAILED MODIFICATION

A. Modification of Radiosonde AN/AMT-4B

The modifications necessary to make humidity circuitry of the radiosonde modulator MD-210/AMT-4 identical to the temperature circuit are as follows: Resistor R-2, normally connected in parallel with the humidity element, was removed (figure 1). At the junction of R-1 and R-2 the blue wire was removed and soldered to the ground-side of relay K-1. This simple modification allows the two temperature elements to be commutated for the duration of the flight. Normally, the humidity sampling is discontinued after 105 of 150 contacts on the baroswitch. The only disadvantage of this modification is that the low reference contacts are no longer available.

Reference drift was corrected as outlined in Federal Meteorological Handbook No. 3, "Radiosonde Observation," under conditions of loss of low reference contacts. High reference contacts were used to correct for frequency drift.

Because of the remote location of the additional thermistor within the Jimsphere, it was necessary to route wiring from the radiosonde to the element. The wire (plastic coated No. 18 gauge) was approximately 9.14 meters (30 feet) long and had a nominal resistance of 3 to 4 ohms. This resistance is small compared to 40,000 ohms of the thermistor, and was considered to introduce a negligible error in the temperature measurements. This resistance was constant, and was therefore compensated for in the baseline calibration.

B. Balloon Temperature Element Support

The support for the temperature element ML-419 was made of balsa wood, because of its weight and strength characteristics. The balsa wood used was one meter (39.37 inches) long with a thickness of 0.635 centimeter (0.25 inch) (Figures 2 and 3).

The piece of balsa wood one meter (39.37 inches) long was glued to the Jimsphere valve wall. This arrangement supported the thermistor and connecting wires, and placed the element near the center of the Jimsphere. Extreme care was taken to prevent puncturing the balloon during insertion and to avoid breaking the temperature element.

IV. INDEX TO DUAL TEMPERATURE FLIGHTS

A. Test No. 1

Date: July 15, 1970

Time: 1423 CDT

Comments: The temperature remained warmer inside the Jimsphere throughout the flight. The helium in the Jimsphere after launch remained approximately 4°C higher than the ambient temperature to an altitude of 3500 meters. From 3500 meters to termination of the flight, the temperature inside the Jimsphere did not decrease at the same lapse rate as the ambient because of the radiation effects being trapped inside the Jimsphere causing a heat sink with a ΔT of 18.1°C at termination (figure 4).

B. Test No. 2

Date: July 16, 1970

Time: 1226 CDT

Comments: The temperature during this daytime flight remained warmer inside the Jimsphere throughout the flight. The gas temperature approached the ambient temperature around 2500 meters because of cloud cover (see surface observation, figure 10). After coming out of the clouds, the temperature inside the Jimsphere increased with height because of radiation effects. At termination, the inside temperature was 24.6°C higher than the ambient or outside temperature (figure 5).

C. Test No. 3

Date: July 16, 1970

Time: 1404 CDT

Comments: This flight was released approximately one and one half hours after test No. 2 and had the same profile with the temperature inside the Jimsphere and the ambient temperature approaching the same value (figure 6). The inside temperature was 24.4°C higher than the ambient at termination (see surface observation, figure 10).

D. Test No. 4

Date: July 16, 1970

Time: 2203 CDT

Comments: The temperature inside the Jimsphere remained cooler than the ambient temperature throughout the flight. The temperature differences were almost always a constant amount except at an inversion level. Inversions set in at approximately 2000 meters and 2750 meters, but the change in the regular tape rate of the inside temperature remained about the same. The response of the temperature inside the Jimsphere to the ambient temperature outside lagged behind by 250 meters. The temperature inside the Jimsphere and the ambient temperature outside approached the same value around 9000 meters (figure 7).

E. Test No. 5

Date: July 16, 1970

Time: 2333 CDT

Comments: The temperature inside the Jimsphere remained cooler than the ambient temperature throughout the flight. This flight was released one and one half hours after test No. 4 and had about the same profile. The inversion at approximately 2500 meters was "washing out," but the one at 2750 meters remained (figure 8). The temperature inside the Jimsphere and the ambient temperature outside approached the same value, approximately 9000 meters.

F. Test No. 6

Date: July 17, 1970

Time: 0055 CDT

Comments: The temperature within the Jimsphere remained cooler than the ambient temperature throughout the flight. This flight was released approximately one hour after test No. 5, and had about the same profile as test No. 4 and No. 5. An inversion at 2700 meters remained, and another developed around 1500 meters. The temperature inside the Jimsphere and the ambient temperature outside approached and crossed around 9000 meters (figure 9).

V. CONCLUDING REMARKS

Since only three flights were made during daylight and three at nighttime, the following observations were made:

During daytime the ΔT temperature between the inside and the ambient is about 4°C up to an altitude of 3500 meters, but increased to approximately 24°C at 9500 meters (figures 4-6). The temperature of the gas inside the Jimsphere does not change as rapidly as does the air temperature outside because the Jimsphere acts as a heat sink.

During nighttime the ΔT temperature between the inside and the ambient remains at a constant difference throughout the flight. The temperature of the gas inside the Jimsphere remained cooler than the air temperature up to an altitude of approximately 9000 meters where they became equal (figures 7-9). Inversions recorded of the air (outside) temperature are reflected on the inside temperature of the Jimsphere approximately 250 meters later.

From this experiment, it is concluded that the temperature inside the Jimsphere during daytime does not decrease near the adiabatic lapse rate as the Jimsphere rises through the atmosphere, but does during nighttime. This experiment also illustrates that, with simple modifications to existing rawinsonde equipment, measurements can be made which are of real value in understanding the physical and dynamic characteristics of the atmospheric parameters or measuring system.

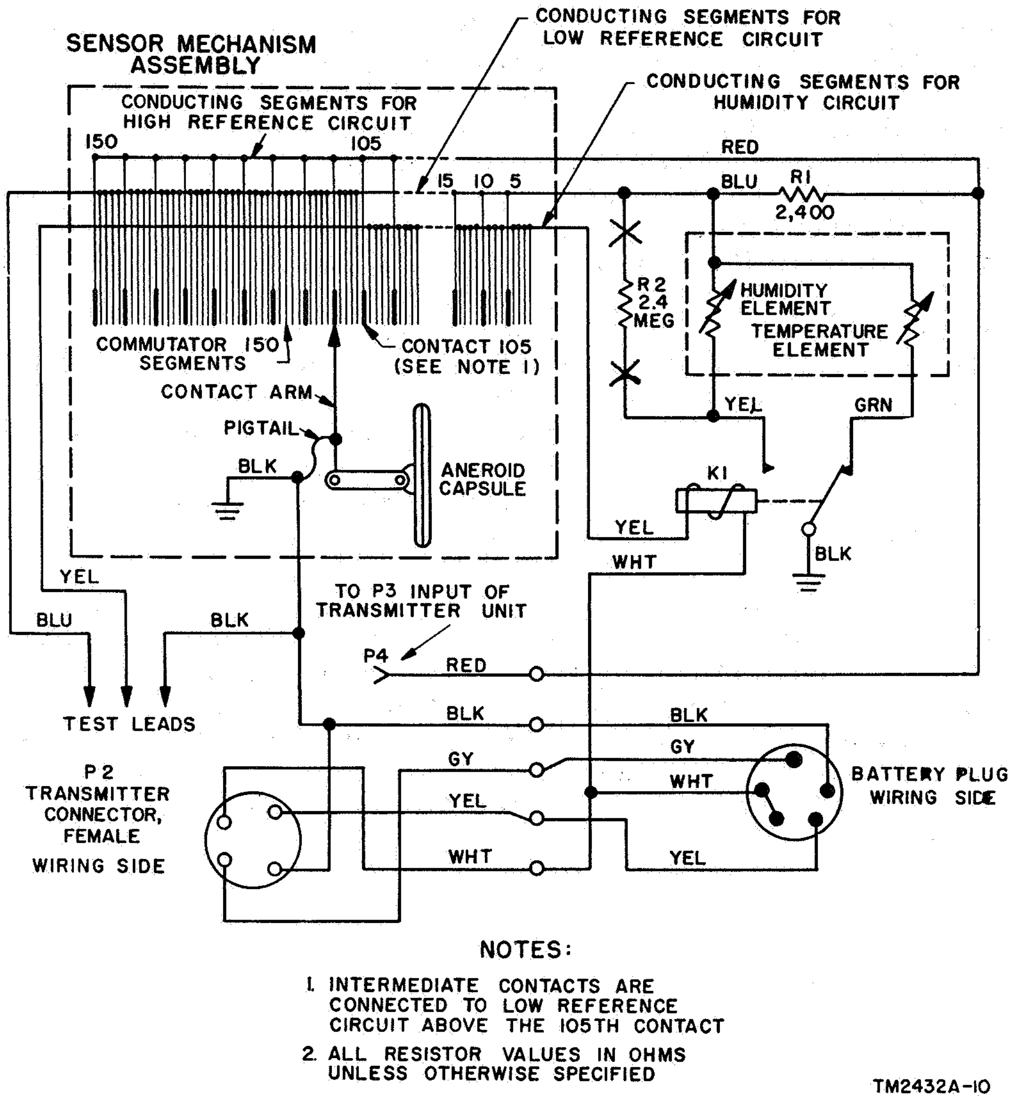

FIG. 1. RADIOSONDE MODULATED MD-210 AMT-4B SCHEMATIC DIAGRAM.

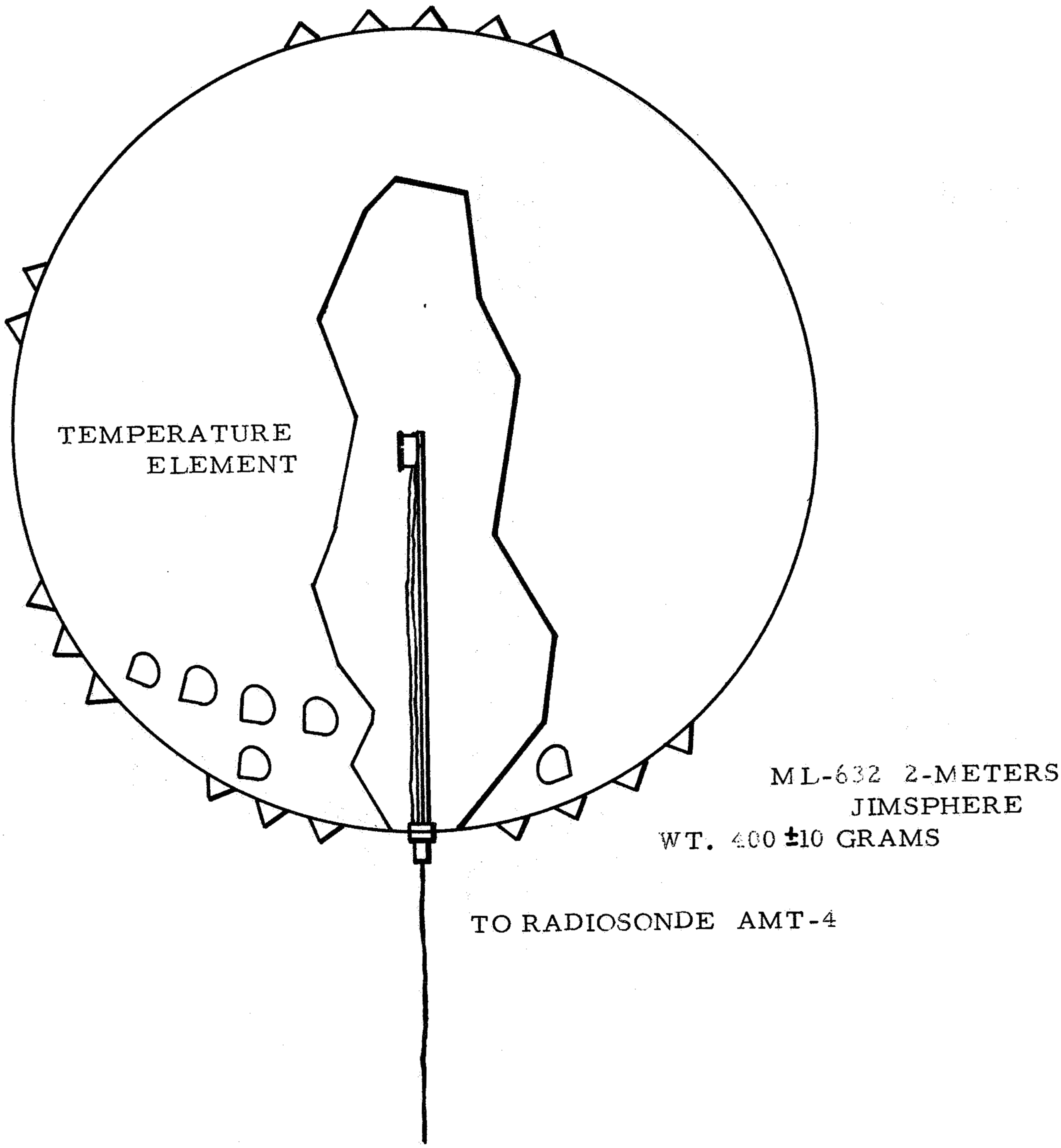

FIGURE 2. JIMSPHERE WITH TEMPERATURE ELEMENT SUPPORT INSTALLED

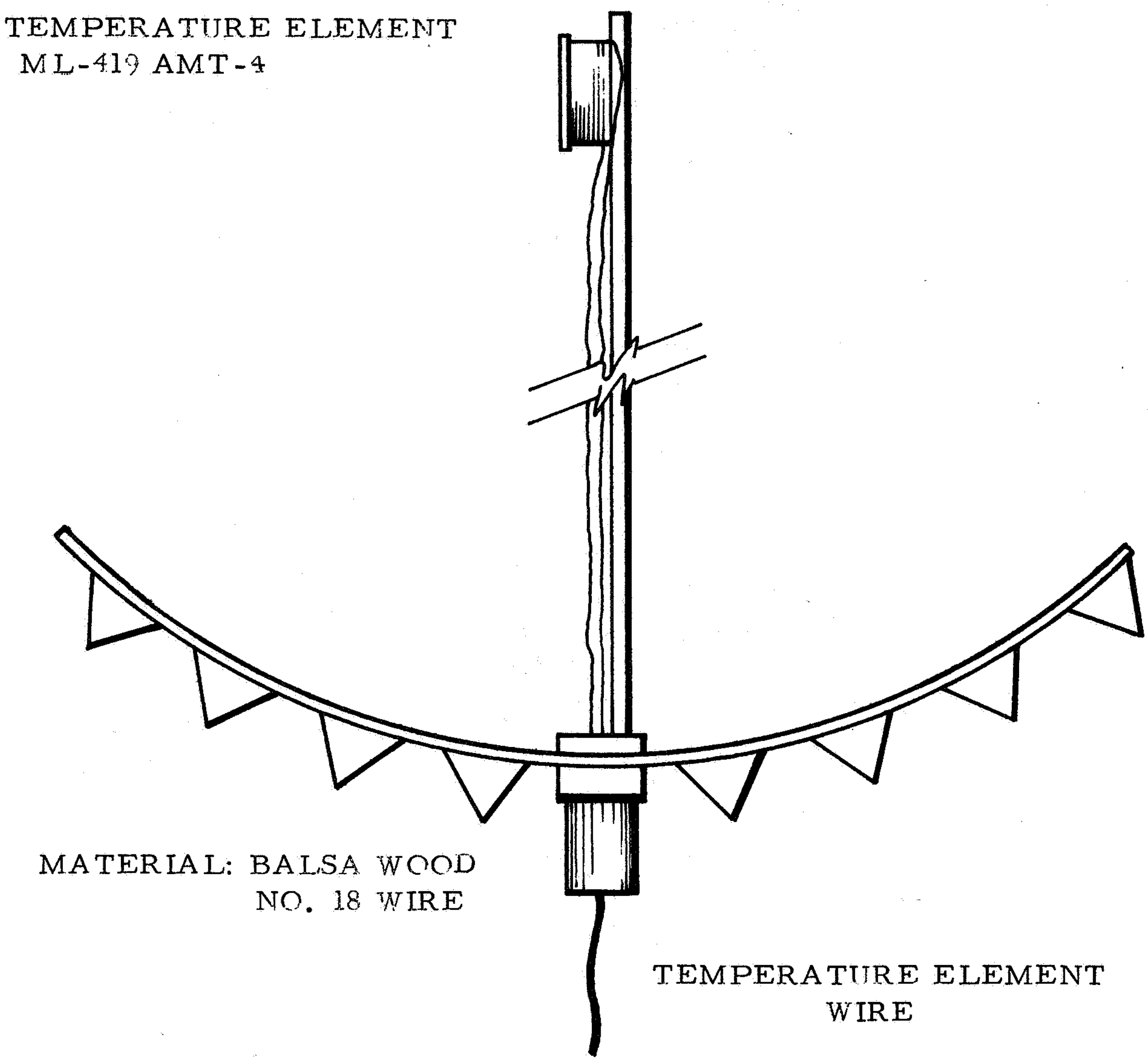

FIGURE 3. TEMPERATURE ELEMENT SUPPORT

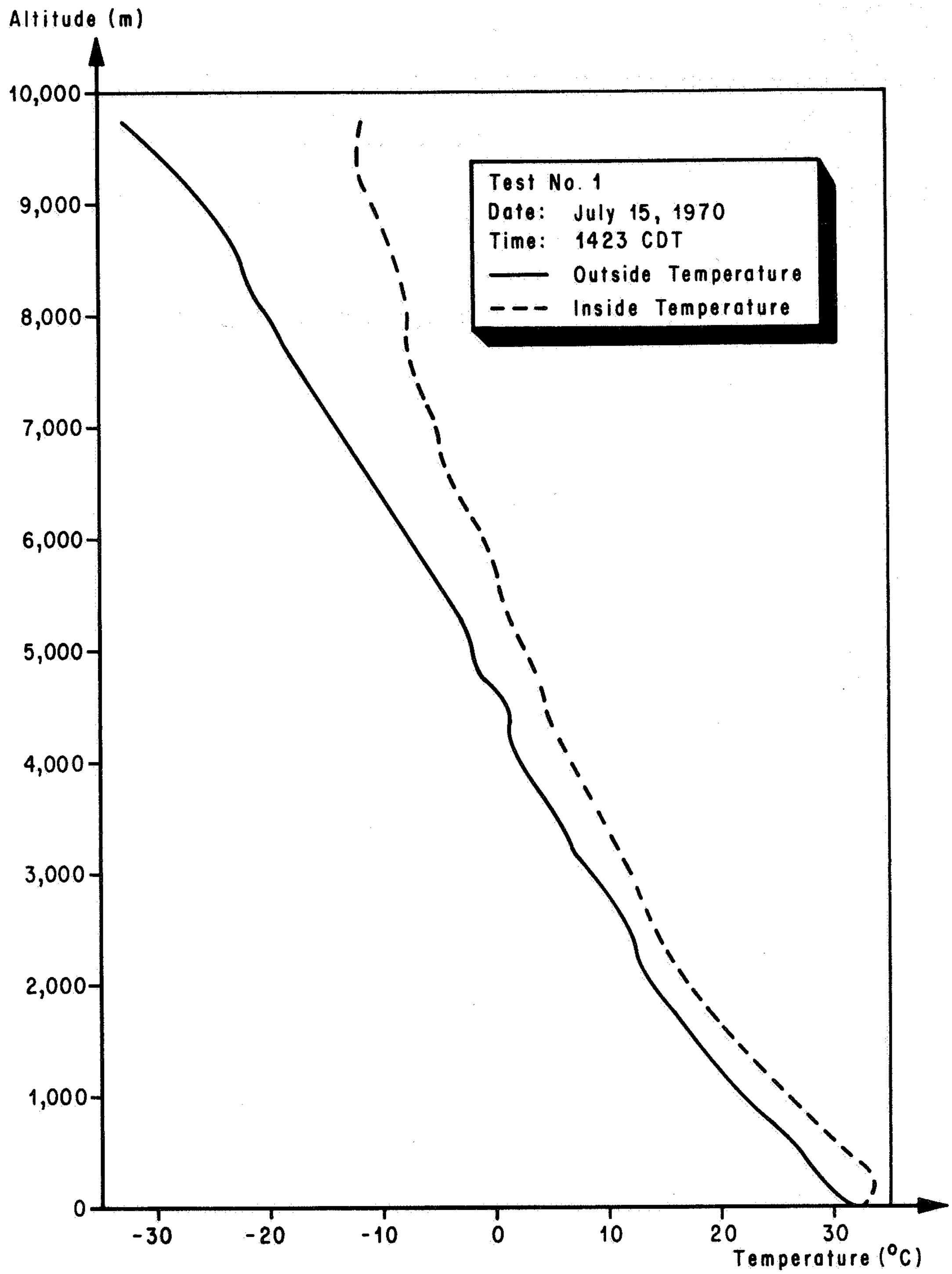

FIG. 4. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE DAYTIME, JULY 15, 1970, 1423 CDT

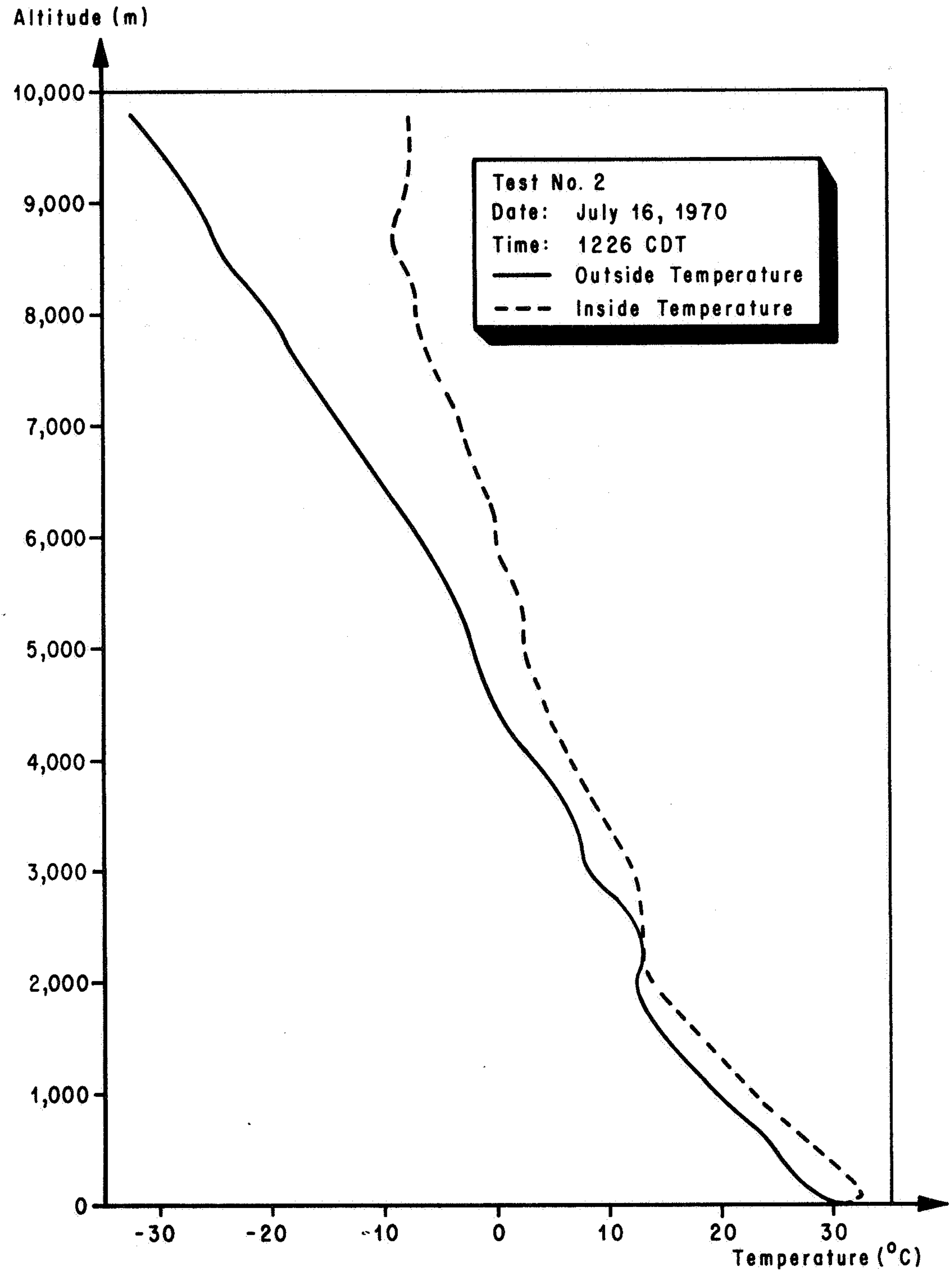

FIG. 5. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE DAYTIME, JULY 16, 1970, 1226 CDT

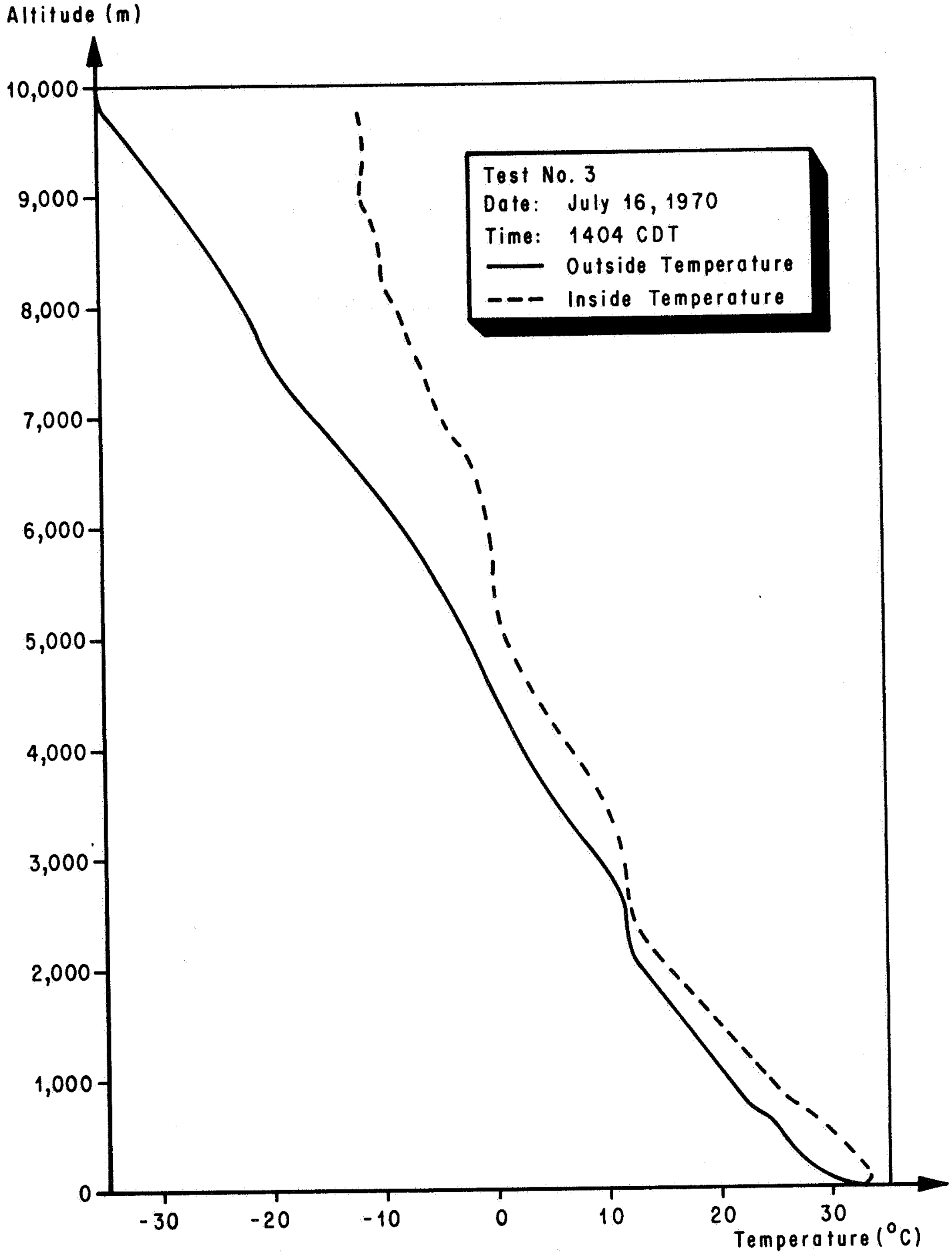

FIG. 6. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE DAYTIME, JULY 16, 1970, 1404 CDT

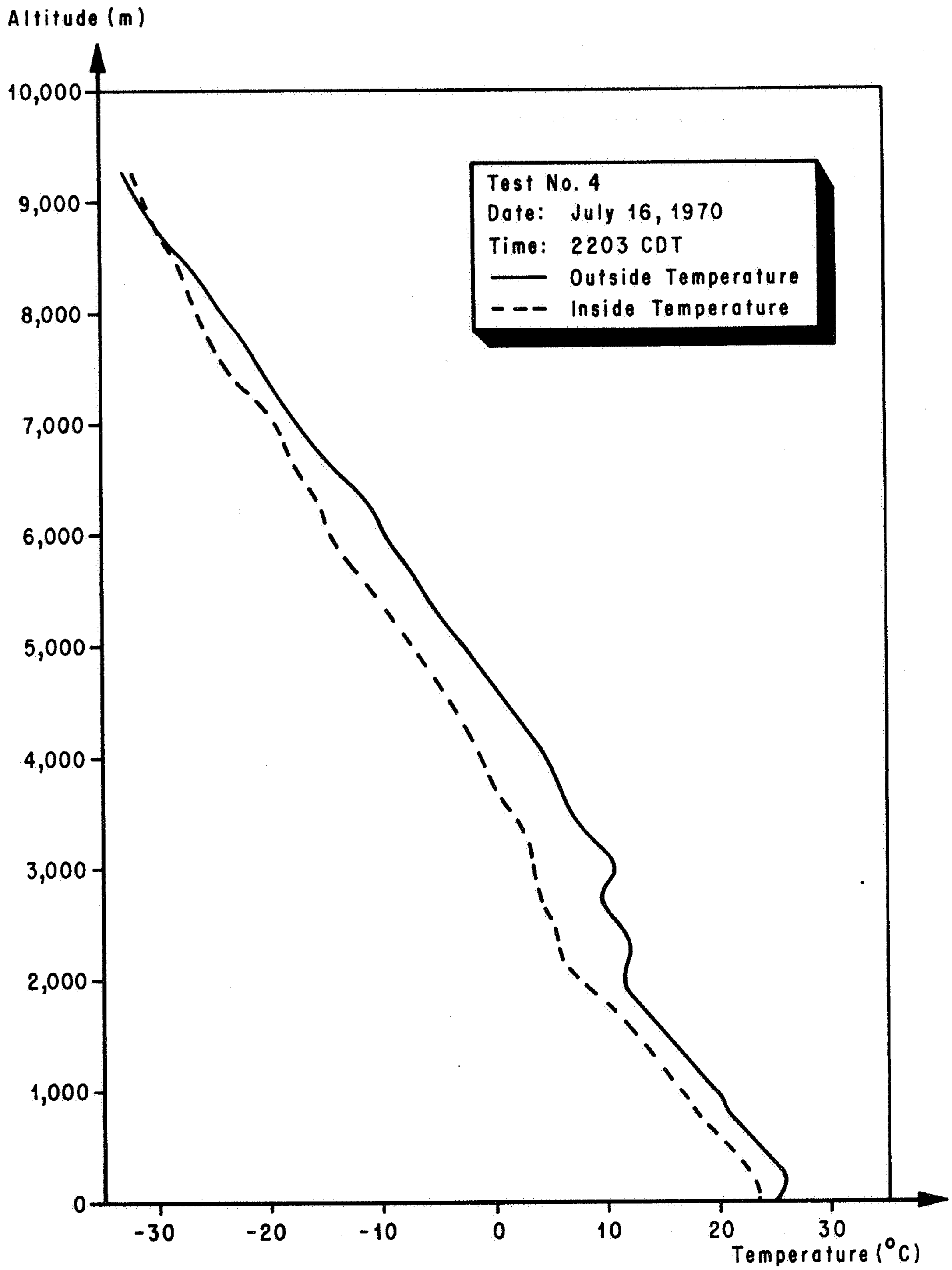

FIG. 7. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE NIGHTIME, JULY 16, 1970, 2203 CDT

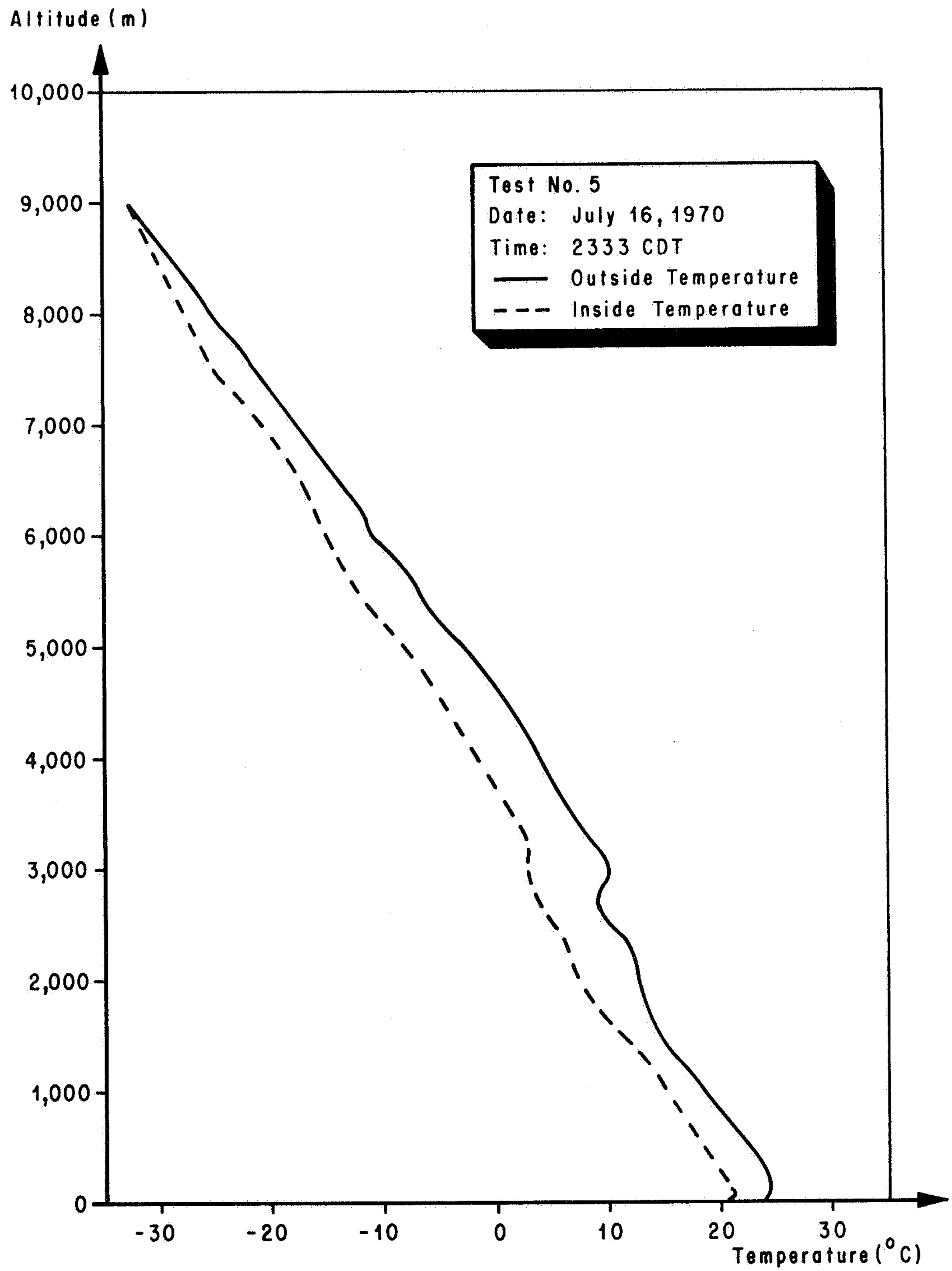

FIG. 8. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE NIGHTTIME, JULY 16, 1970, 2333 CDT

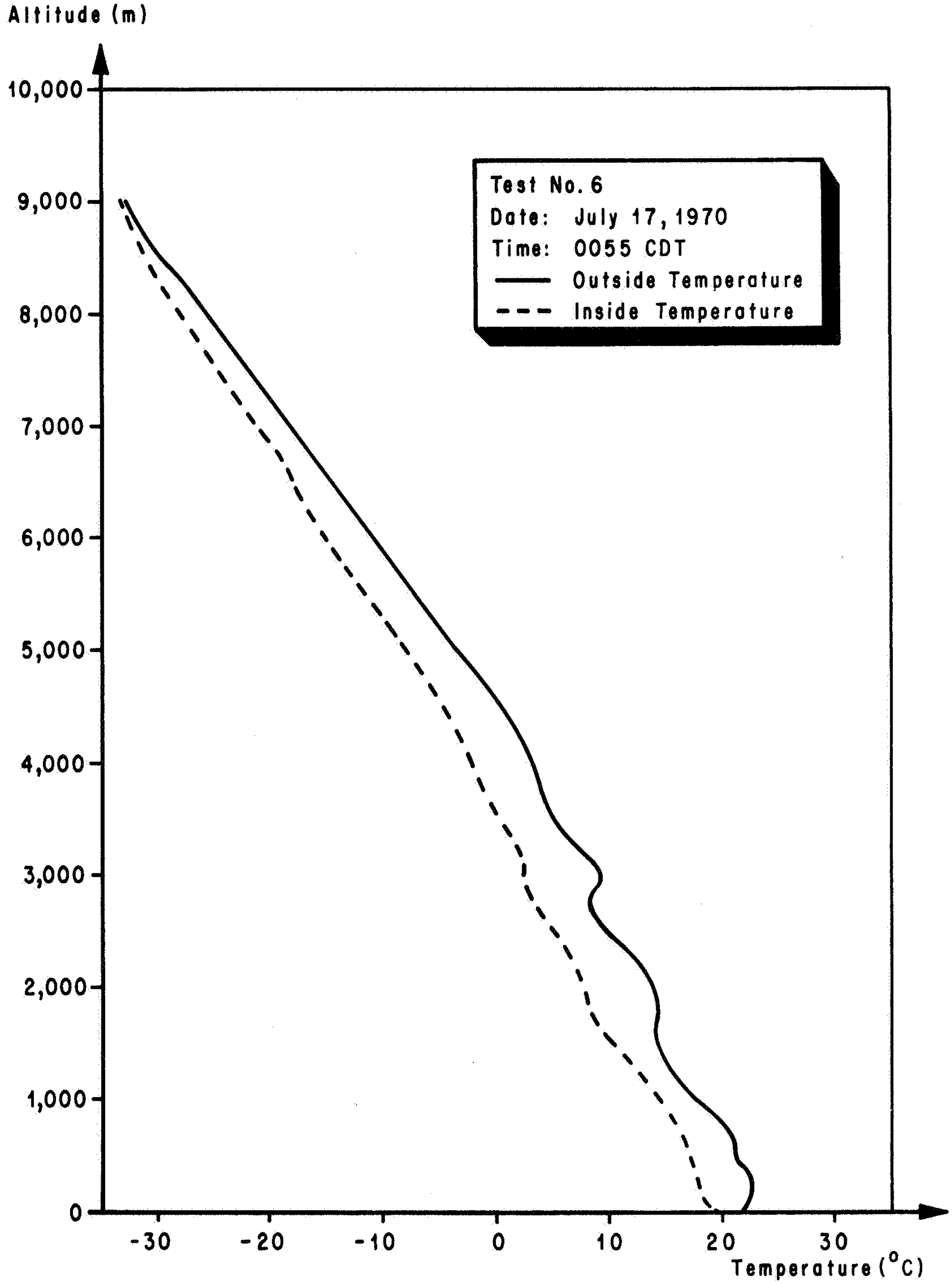

FIG. 9. TEMPERATURE MEASUREMENT INSIDE-OUTSIDE JIMSPHERE NIGHTIME, JULY 17, 1970, 0055 CDT

Date	Time (LST)	Sky and Ceiling (Hundreds of Feet)	Visib. (mi)	Temp. (°C)	WIND		Station Pressure (mb)	Dry Bulb (°C)	Wet Bulb (°C)	Rel. Humid. (%)	Tot. Sky Cvr.	CLOUDS AND OBSCURING PHENOMENA						REMARKS
												Lowest Layer			Second Layer			
					Direc-tion (deg)	Sp'd. (mps)						Amt.	Type	Ht. (ft.)	Amt.	Type	Ht. (ft)	
8/15/70	1423	50⦶ E100 ⦷	10	32	220	3.5	997.8	32.3	23.1	45	6	5	CU	50	1	AC	E100	
8/16/70	1226	E45⦷ 180 ⦷	10	31	270	2.0	996.0	30.6	22.8	52	8	6	CU	E45	2	AC	180	TCU ALQDS
8/16/70	1404	40⦶ E300 ⦷	10	32	290	3.5	995.3	31.7	22.0	43	8	4	CU	40				
8/16/70	2203	E50 ⊕	10	23	310	1.0	995.1	23.2	19.3	70	10	10	SC	E50				
8/16/70	2333	300⦶	10	20	340	1.0	995.1	20.3	18.1	81	2	2	CI	300				
8/17/70	0055	300⦶	10	20	320	0.5	995.8	19.5	17.2	80	2	2	CI	300				

FIGURE 10. SURFACE WEATHER OBSERVATIONS

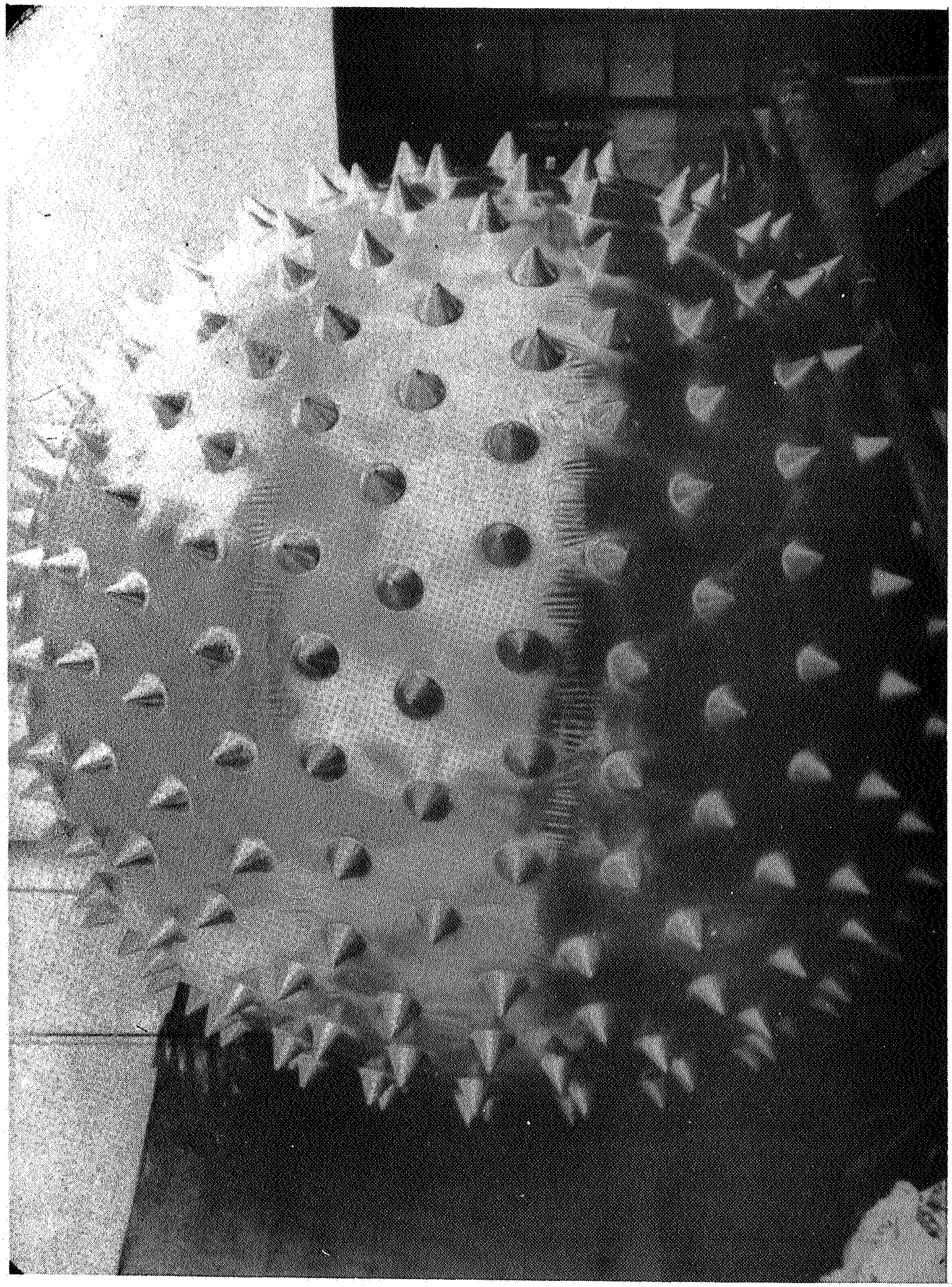

FIGURE 11. THE JIMSPHERE BALLOON WIND SENSOR

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